High Power Activity: NASA's Deep Impact Mission

Decision Making

PROPOSAL FOR OPTIONAL ONBOARD PUBLIC VIEWING CAMERA

The following proposal is based upon an actual document received by NASA for additional cameras to be placed upon the Deep Impact spacecraft (on both the flyby spacecraft and impactor) to capture images of the spacecraft and hardware during the mission. Specific language has been removed to result in a general guide for the learner in his/her study. Definitions of some terms are included in italics for student use.

<u>Deep Impact Mission Partnership</u>:

I. Introduction

The Deep Impact mission will be the first attempt to probe deep beneath the surface of a comet, permitting scientists to uncover clues about comets and the formation and evolution of the solar system. This is a highly complicated mission, involving six years of planning and teams of scientists from around the world. The result will be dramatic: an 820-lb projectile impacting with the comet while traveling 22,000 mph. The public will surely be fascinated by this space collision, but how will they understand the science behind the mission, the planning involved, and the greater purpose it serves for humankind?

Space Video, Inc. seeks to partner with the University of Maryland and NASA to bring this incredible story to the public—on television, online, in schools, and through Space Video, Inc.'s other public outreach activities. Our collective goal will be to capture our nation's imagination about space and the Deep Impact mission through multi-year media coverage and documentation that leads up to the 2005 Deep Impact event. We hope this partnership will stand as an example of effective space commercialization, where a corporate partner and non-profit institutions gain mutual advantage from space exploration.

II. Space Video, Inc. Proposed Enhanced Mission Coverage

Scientists at the University of Maryland have provided for **baseline imaging** *(records scientific data and pictures before, during, and after the impact on the comet).* The Deep Impact mission's baseline imaging instrumentation consists of three cameras and an **infrared spectrometer** *(an instrument that measures energy and is used in this mission to analyze the structure and composition of the comet).* While the mission already has the equipment to provide detailed images for monitoring and observing the comet's nucleus, Space Video, Inc. proposes additional instrumentation to enable full coverage of the Deep Impact mission. Space Video, Inc. will fund the purchase, installation, and operation of additional cameras on the spacecraft and launch rocket. These additional enhancements would allow scientists and the public to also view the flyby spacecraft, impactor, and hardware in action throughout the mission (see pages 4 and 5 for pictures of flight system and instrumentation). The proposed image enhancements are outlined below.

- Add up to four small cameras to the **flyby spacecraft** (*transports, releases, and observes the impactor hitting the comet*). Cameras could relay images of the:
  - **Impactor** (*the 820-lb mass that will make a crater in the comet*) as it moves away from the flyby spacecraft. Such images would verify the actual release of the impactor as well as determine the release velocity.
  - Comet **nucleus** (*the solid center component made of ice, gas, and rocky debris*) during approach.
  - **Dust shields** to show images of dust impacts and any resulting damage. *(**Dust shields** provide protection for the flyby spacecraft and its instruments from small particles in the inner coma or atmosphere of the comet that could cause damage.)*

  - **High Gain Antenna (HGA)** to show it pointing. (*The **HGA** relays the data and images back to the Earth-based antennas such as the Deep Space Network.)*
  - **Solar arrays** to show deployment or proper functioning. *(Two **solar array** panels will provide power to the Deep Impact spacecraft.)*

- Add up to two similar cameras to the impactor. Cameras could relay images of:
  - Flyby as the impactor moves away to determine release velocity.
  - Dust shields to show images of dust impacts.

In exchange, Space Video, Inc. will be provided special access to mission team members and to mission information to aid in the production of Space Video, Inc.'s television and online programming.

III. Technical Issues

All equipment must be approved by the Deep Impact project team and meet the technical specifications outlined below.

- Any changes to hardware are solely on a "best-efforts" basis, *i.e.*, mission will not be delayed to accommodate problems.
- Hardware enhancements should improve science, if possible, or at least boost engineering confidence in addition to providing **outreach images** *(images released to the public)*.
- Any changes to hardware must not threaten schedule, cost, or **mass margin.** *(This sets limits on the amount of matter allowed on board a spacecraft in order to ensure a successful lift-off during launch and spacecraft flight. The mass margin cannot exceed 20% of the launch mass.)*
  - *The following equation is used to determine the mass margin for the Deep Impact mission:*

$$\textit{Deep Impact Mass Margin} = \frac{1010\text{kg} - (\text{known mass} + \text{estimated mass})}{1010\text{kg}}$$

- ***1010 kg (or 2,020 lbs) = the launch mass*** *(the maximum amount that can be propelled into space by the Boeing Delta II 2925 launch vehicle)*
- ***known mass*** *(the mass of the spacecraft parts that have already been assembled)*
- ***estimated mass*** *(the expected mass of parts that have not been built or assembled yet)*

In the proposed improvements, Space Video, Inc. has taken into consideration potential risks to the mission schedule and has determined the following:

- Several enhancements, with significant scientific payoff, have been rejected as too risky to our schedule. These involve an increase in **bandwidth** (*the amount of data that can be passed along a communications channel in a given period of time*). Increased bandwidth between impactor and flyby could communicate more total data from impactor, and increased bandwidth between flyby and Earth could reduce risk by providing more real-time data; however, these increases could threaten to delay the mission schedule.
- Selected enhancements are stand-alone hardware items that have very little ripple-through effect on our schedule. Consequently, they can be dropped at any point with no effect on the baseline design.

IV. Design Challenges

Space Video, Inc. has identified several design obstacles that require careful consideration.

- Launch vehicle cameras take 2.5 kg (5 lbs) from mass margin; flyby cameras take up to 1 kg (2 lbs) from mass margin.
- Best images of dust hits on impactor will occur late in the approach; unfortunately, during the encounter, these images must be held back to avoid the risk of interfering with science data.

- Although most flyby cameras are sending data when there is very little scientific data to be sent, the dust-impact camera provided by Space Video, Inc. would take its best data when scientific data has absolute control of the real-time link to Earth. These data would need to be stored on board.
- If additional personnel cannot be found at **Ball Aerospace and Technologies Corporation (BATC)**, design, integration, and test tasks could take time of people needed elsewhere on the project.

V. Scientific and Outreach Advantages of Enhancements

The additional cameras proposed by Space Video, Inc. will provide the following benefits:

- **Separation velocity** (*the speed and direction of the impactor after its release from the flyby spacecraft*) of impactor from flyby is now the largest uncertainty in our baseline method for predicting the time of impact and, thus, the timing of our data-taking sequence. Determining the separation velocity could improve our prediction from plus or minus two seconds to plus or minus one second, thus improving data quality.
- Low-**resolution** (*the fineness of detail that can be distinguished in an image, as on a video display terminal*) video images of the comet's nucleus during **shield mode** provide new angles of the nuclear shape and enable creation of a better three-dimensional model of the nucleus. (*In **shield mode**, the spacecraft is turned so that its shields face oncoming cometary debris, therefore protecting the spacecraft from damage.)*
- Images of dust impacts can provide important information on the mass of the large dust particles and allow **calibration** (*the act of making instruments agree with an already-existing standard*) of the momentum transfer detected by the **Attitude Determination Control System (ADCS).** (*This system is necessary to know the orientation of the spacecraft with respect to different reference points and to be able to command the spacecraft to desired orientations.*)
- Images of movable parts (antenna and solar arrays) provide engineering reassurance that components have deployed correctly and provide crucial problem-solving information if the components do not function properly.
- The enhancements provide the public with a number of new images of space.
  - First-ever imaging sequence showing spacecraft separation in deep space.
  - First-ever images of actual dust hits damaging the spacecraft dust shields.
  - First-ever imaging sequences of hardware deployment and communication in deep space.

VI. Imagery Rights

Space Video, Inc. would have free—but not exclusive—access to the Deep Impact mission's baseline images (from the three existing cameras and spectrometer). In return for funding the enhanced imaging equipment, Space Video, Inc. would have ***exclusive ownership*** and use of any "enhanced images" taken from Space Video, Inc.-funded cameras described above. These images would be made available to NASA and the University of Maryland free of charge throughout the mission for scientific purposes only; however, after a one-year, post-impact period of exclusivity, Space Video, Inc. would release the images for public and commercial use.

Space Video, Inc. recognizes that NASA, in its public charter, must provide equal opportunity to all commercial partners. Therefore, Space Video, Inc. proposes that if other media entities are interested in gaining access to the enhanced images during the period of exclusivity, they may do so by paying an equal portion of the enhancement funds.

** **Editor's Note**: Space Video, Inc. wants **exclusive ownership** in order to protect their investment and maintain sole control over the use and distribution of any pictures that were taken using the additional cameras they funded.*

PICTURES OF DEEP IMPACT MISSION SPACECRAFT, HARDWARE, AND INSTRUMENTATION

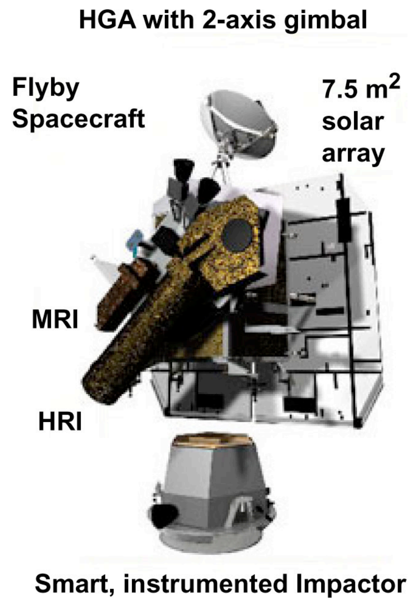
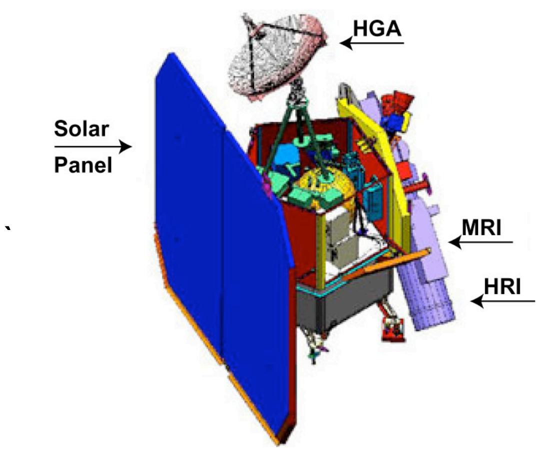
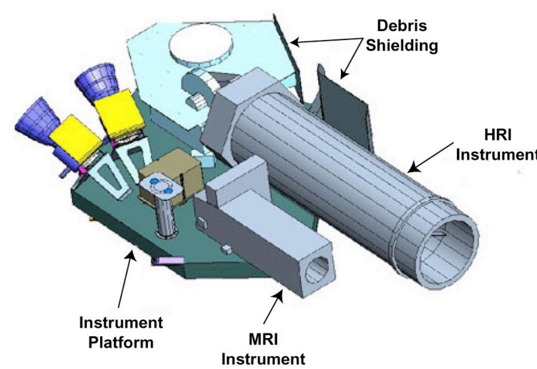


Diagram of the Deep Impact Mission Flight System





Diagrams of the Flyby Spacecraft

- *High Gain Antenna (HGA) relays data back to Earth.*
- *Solar panel provides power to the spacecraft.*
- *High Resolution Instrument (HRI) is the primary instrument. Consists of a telescope, digital camera, and infrared spectrometer.*
- *Medium Resolution Instrument (MRI) functions as a backup to the HRI. Consists of a telescope and camera.*
- *Debris Shielding protect the flyby spacecraft from potentially damaging small particles in the atmosphere of the comet.*

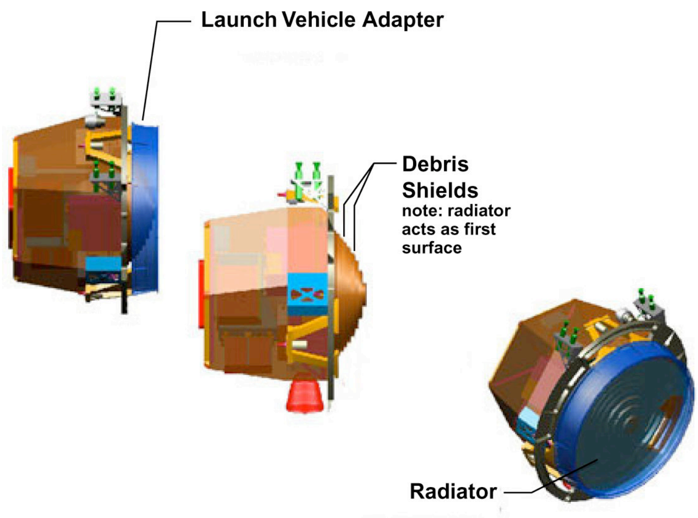


Diagram of Impactor: *This 820-lb mass will collide with the comet and create a crater in order for scientists to view the comet's nucleus*